A Web-Based Course Assessment Tool with Direct Mapping to Student Outcomes

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ABSTRACT

The assessment of curriculum outcomes is an essential element for continuous academic improvement. However, the collection, aggregation and analysis of assessment data are notoriously complex and time-consuming processes. At the same time, only few developments of supporting electronic processes and tools for continuous academic program assessment and curriculum performance feedback have emerged. In this paper, we introduce a novel course assessment process supported by a Web based interface that articulates and streamlines the assessment data collection, performance evaluation and tracking of remedial recommendations. To close the assessment loop, the Web interface provides also a mechanism to follow up on the implementation of remedial recommendations and analyzes their associated reflective actions during the subsequent course assessment cycle. A guide to map assessment instruments to the course and overall program outcomes is advocated by the proposed tool to propagate the course assessment results towards higher educational objectives (e.g., student outcomes) in a dashboard-like assessment interface. This approach streamlines improvements in education through reflecting the achievement of course outcomes on the achievement of higher educational objectives. In addition, the tool maps the course outcomes to the corresponding course outlines to facilitate the detection of areas where revisions in the instruction and content is needed, and to best respond to recommendations and remedial actions. We provide a methodical approach as well as a Web-based automation of the assessment process, which we evaluate in the context of our regular academic assessment cycles that have eventually led to a successful international accreditation experience. The collected assessment data shows a significant improvement in the achievement rate of the student outcomes after deploying the tool.

Keywords

Web-based services, Course assessment, Student outcomes, Accreditation

Introduction

Education assessment refers to all activities which pro-vide information to be used as feedback to revise and improve instruction and learning activities (Black & William, 1998). Assessment outlines the foundation for continuous quality improvement and is considered to be a key element of educational processes. Two educational assessment models can be identified in the literature, namely the curriculum-based and the outcomes-based models. The curriculum-based model assesses learning retention based on the quality of the curriculum presented to the students and the learning methods implemented by the institution. The outcomes-based model, on the other hand, focuses on what the students should know and can actually do after completing their study requirements.

Lately, a new trend in educational assessment has been observed as more academic institutions are moving away from the traditional curriculum-based assessment models towards outcomes-based ones (Gardiner, 2002; Harden, 2002). Few factors have contributed to this new trend including some recent studies, which show that even students enrolled in respected academic institutions often fail to exhibit fundamental understanding of basic concepts and fairly easy physical systems (Harden, 2007). This is mainly because curriculum-based models do not usually make clear statements as to what students are expected to achieve upon completing a program of study. Having a carefully designed curriculum and a highly qualified faculty do not necessary mean that students comprehend the offered material. Therefore, to improve the efficiency of learning processes, academic institutions are increasingly adopting outcomes-based approaches for curriculum design (Harden, 2002). This shift makes them focus more on assessing the expected outcomes of the educational experience rather than the quality of the offered curriculum.

To ensure continuous improvements, the outcomes-based model relies on routinely and objectively assessing some standard learning outcomes along a comprehensive assessment cycle. The main components of this assessment cycle are illustrated in figure 1. During each cycle, suitable assessment instruments (or tools) are used to collect relevant assessment data for targeted outcomes meant by a given assessment exercise. The collected data are then analyzed

and compared against the intended objectives. An assessment cycle is closed once proper recommendations are elaborated and remedial actions are implemented to address revealed deficiencies.

This widespread interest in the outcomes-led model is also driven by the accreditation prospects of academic institutions. Wergin (2005) mentioned that accreditation was the topic of more than 1,300 journal articles between 2002 and 2004. He also argued that the recent interest in academic accreditation is mainly because it is the only organized way by which an institution can convey quality assurance to the public. The accreditation board for engineering and technology (ABET) also believes that obtaining accreditation makes an institution in IT and engineering disciplines a better choice for students because it indicates that the students will gain standard knowledge and skills necessary to be productive members in contemporary professional careers. ABET accreditation exercise puts a strong emphasis on the outcomes-based model. Recently, the Canadian engineering accreditation board (CEAB) has also updated its accreditation criteria to adopt the outcomes-based model as well (Brennan & Hugo, 2010).

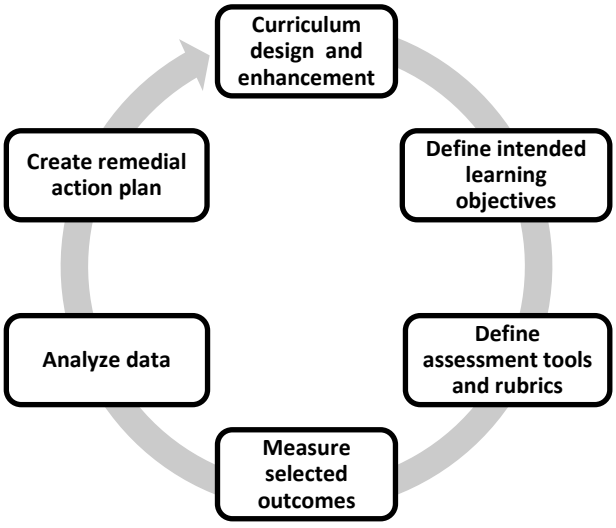

Figure 1. Information technology assessment plan

Recently, Al-Yahya and Abdel-Halim (2013), discussed their Electrical Engineering Department successful experience with outcomes based assessment of their program, which led to ABET accreditation. They describe preparations and the procedures followed to implement an evaluation system for the program by incorporating assessment of outcomes as well as a continuous improvement mechanism to develop and enhance the program. Their assessment model is based on two processes, an outer loop to evaluate the Program Educational Objectives (PEOs) once every four years and an inner loop, more frequently executed to evaluate the course and program outcomes, typically every year (Rogers, 2012). A unified approach to support outcomes based assessment has been investigated.

In Europe, outcome based assessment also gained momentum in the recent years (Crespo et al., 2010). Crespo et al., (2010) provided information on the different initiatives taken to support a unified conceptual map for outcome based assessment. They proposed a theoretical framework to integrate several concepts including learning outcomes, assessment processes and learning units. This increasing adoption of the outcomes-based assessment model has subsequently resulted in a considerable debate on how academic institutions can best define, assess, and evaluate learning outcomes. In this paper, we propose to streamline these processes through systematic electronic services featured by a Web-based assessment tool that is currently in use to capture the course-outcomes assessment results of an Information Technology curriculum. This development revealed that the performance of this curriculum could be tuned effectively by closing the assessment loop shown in figure 1, through automatically tracking recommendations and their associated remedial actions.

The Web based tool has the following benefits: (1) integrates planning and assessment in a systematic way; (2) maintain assessment records; (3) keep assessment agendas on track, with scheduled tasks for different levels; (4)

apply a uniform assessment model throughout the educational enterprise; and (4) root-out curricular deficiencies in a systematic way. Throughout this paper, we integrated the following contributions: (1) a combined assessment model to streamline the intricacies involved across section offerings of a course within a large academic institution, (2) a computational formulation of assessment results collected at course levels and reflected at program levels, (3) a data model to arrange relevant assessment indicators into a composite structure, and (4) a portal application to automate assessment processes for stakeholders involved in assessment cycles. We also report a successful experience of integrating the proposed model and deploying the suggested portal application into an actual academic assessment exercise, which we evaluate through a case study. Adding to the above benefits, this work has a twofold research value. First, we consolidate several modules of the assessment process, which used to be addressed separately in the literature. In doing so, we introduce new parameters to regulate the assessment standards of an institution and integrate the associated modules into a comprehensive assessment system. Secondly, we observe and report the results of actual experiments to gauge the effects of this streamlined approach. The outcomes of these contributions support further solutions to expand the scope of technologically enhanced education processes, at large.

The rest of this paper is organized as follows. Section 2 motivates the current needs for an effective assessment management system. Section 3 reveals our course assessment model and related processes. Section 4 presents the organization of assessment data. Section 5 provides the architecture of the supporting tool. Finally, Section 6 concludes the paper with an evaluation of the proposed tool in the context of actual case studies and reports some of the related lessons learnt from this experience.

The need for streamlining academic assessment

While outcomes assessment offers great promises for improving student learning, existing processes for integrating learning outcomes, collecting resulting data and analyzing student performance are limited. They are typically labor intensive, paper-based, and often exclusively driven by accreditation visits or other ad-hoc considerations. For example, the University of Alberta, Edmonton, Canada, estimated that the preparation for the last CEAB accreditation review of their nine engineering programs had cost them over $1 M and required the collection of more than a ton of documents, and 16,000 man/hours of preparation time (Dew et al., 2011).

The above example demonstrates the massive amount of administrative load that needs to be carried out by the faculty of an academic institution, while preparing for an accreditation visit. Overwhelming the faculty with administrative work, especially at the early stages of enforcing assessment processes, might trigger resistance against any resulting recommendation for changes to existing course contents and teaching practices. However, securing the support and the commitment of the faculty is essential for a successful implementation of assessment processes. Therefore, to effectively engage the faculty, course assessment processes should be as simple and efficient as possible, and integrate seamlessly with curricular components and teaching practices. A streamlined approach to automate academic assessment processes, alleviate the induced intricacies and reduce the associated load.

Although closing the assessment loop is essential for continuous quality improvement of a curriculum, it is usually the most overlooked part, and is typically where the assessment efforts get disrupted at the various levels. For example, at the course level, our own experience indicates that course coordinators usually terminate the assessment process after reporting the collected assessment results. They do not usually close the assessment loop by analyzing collected assessment data and creating appropriate recommendations and remedial actions to address any detected shortcomings in the learning process.

At the program level, however, the main problem is usually related to compiling the enormous amount of heterogeneous data collected from different course assessment exercises and using different assessment instruments (e.g., survey results, exit interviews, etc.). This federation of assessment data across program courses needs to be further converted into useful information that accurately reflects the achievement levels of student outcomes to facilitate curricular decisions. Failing to do so, may affect the correctness of the assessment results and could lead to ineffective or even wrong remedial actions.

Therefore, there is currently a clear need for automating the assessment workflows in higher education institutions. An assessment management system could effectively streamline the collection and analysis of assessment data. It will also contribute to lowering the complexity of the assessment processes, reducing the administration load

assigned to faculty, and seamlessly weaving assessment exercises into existing teaching methods. Unfortunately, there are only few developments of such electronic processes and tools for continuous program assessment and feedback (Dew et al., 2011; Kerr, 2011; Essa et al., 2010; Booth, 2006). However, most of these systems have been designed in an ad-hoc way fulfilling the needs of a specific institution. For example, an accreditation management system has been developed and customized for the college of engineering at the University of Alberta, to satisfy the CEAB's accreditation requirements (Dew et al., 2011). Similarly, an ABET course assessment tool (ACAT) system (Essa et al., 2010) was designed and developed to assist faculty at University of Nevada, Reno, in producing course assessment reports for ABET accreditation. Although it was designed for ABET accreditation, ACAT system deals only with the assessment at the course level and does not propagate the course assessment results to student outcomes (SOs) or PEOs.

Electronic assessment or e-assessment has been used in the evaluation of educational processes. E-assessment was defined in (Joint Information Systems Committee, 2007) as "the end-to-end electronic assessment processes where information and communication technology is used for the presentation of assessment activity, and the recording of responses. This includes the end-to-end assessment process from the perspective of learners, tutors, learning establishments, awarding bodies and regulators, and the general public". Although e-assessment is mostly associated with assessment at the course level, the idea can be propagated to program assessment, in which a course assessment plays a cornerstone role. One of the main advantages of the use of e-assessment is attributed to the automatic and instant feedback, which is generated based on collected and processed data, to prompt parties involved in the assessment cycle to take necessary actions based on their predefined roles. Thus, the idea of using computerized tools and processes to effectively automate the assessment cycle of a particular program is appealing as it prevents information overload, limits roles of stakeholders to essential tasks, instills process uniformity and prompts just-in-time actions.

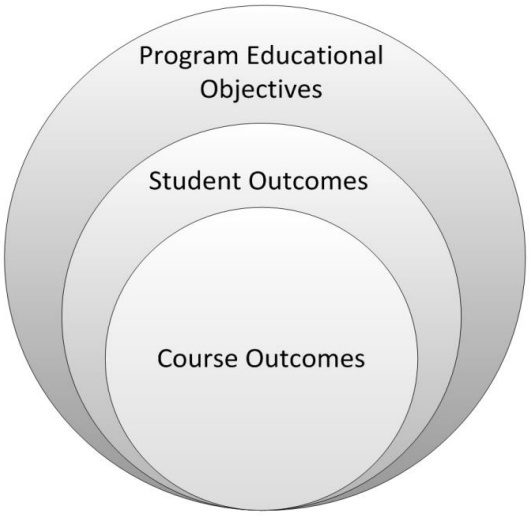

Figure 2. Information technology program assessment hierarchy

Assessment methodology

We have recently implemented a comprehensive assessment and evaluation system as part of our efforts in preparing our Bachelor of Science in Information Technology program for accreditation by ABET. However, this effort resulted in a sustained activity beyond the accreditation goal. The assessment system consists of three main processes based on ABET guidelines (Sanderson, 2009) as shown in figure 2. At the lower level, the course assessment process is used to measure the achievement of course outcomes (COs). COs describe the knowledge, skills, and/or competencies that the students should have or be able to demonstrate upon completion of the course (Yue 2007). COs assessment results are then combined with other program-level assessment tools (e.g., student survey, exit exams, exit interview, etc.) to measure the achievement of the SOs at the next stage. SOs describe what students are expected to learn and be able to do by the time of their graduation (Sanderson, 2009), which include cognitive, affective, behavioral, social, and ethical performances (Wyne, 2010). At the third level, the PEOs (Williams, 2010)

are measured and evaluated. PEOs are broad statements that describe the strategic career and long-term professional accomplishments the program is preparing its graduates to achieve 3-5 years after graduation.

Although COs were regularly assessed by the end of each course-offering since the deployment of our curriculum in 2005, the legacy course assessment process had several drawbacks that diminished its effectiveness, which include:

- Missing a formal evaluation and feedback mechanism.
- Missing a standard mechanism for compiling the assessment data collected from multiple section offerings of the same course. The assessment of COs was done at the section level, where instructors assess the outcomes based on their individual section assignment, and submit their assessment reports to the course coordinator.
- The assessment data was subject to class gender (as separate male and female classes are scheduled in our institution), and the number of students per section.
- No unification of assessment tools at the course level. Different assessment tools were used by different instructors to evaluate the same CO. Therefore, it was difficult to compile the assessment results together to generate the overall course assessment report.
- Lack of automation. Although softcopies of all assessment reports (PDF format) were regularly stored in a dedicated assessment repository, it was very difficult to extract the assessment results (automatically) and propagate them across a higher-level to assess strategic objectives (e.g., SOs, and PEOs) as shown in Fig 2. It was also difficult to track the corrective recommendations and their implementation to address remedial actions and link them to their assessment origins.

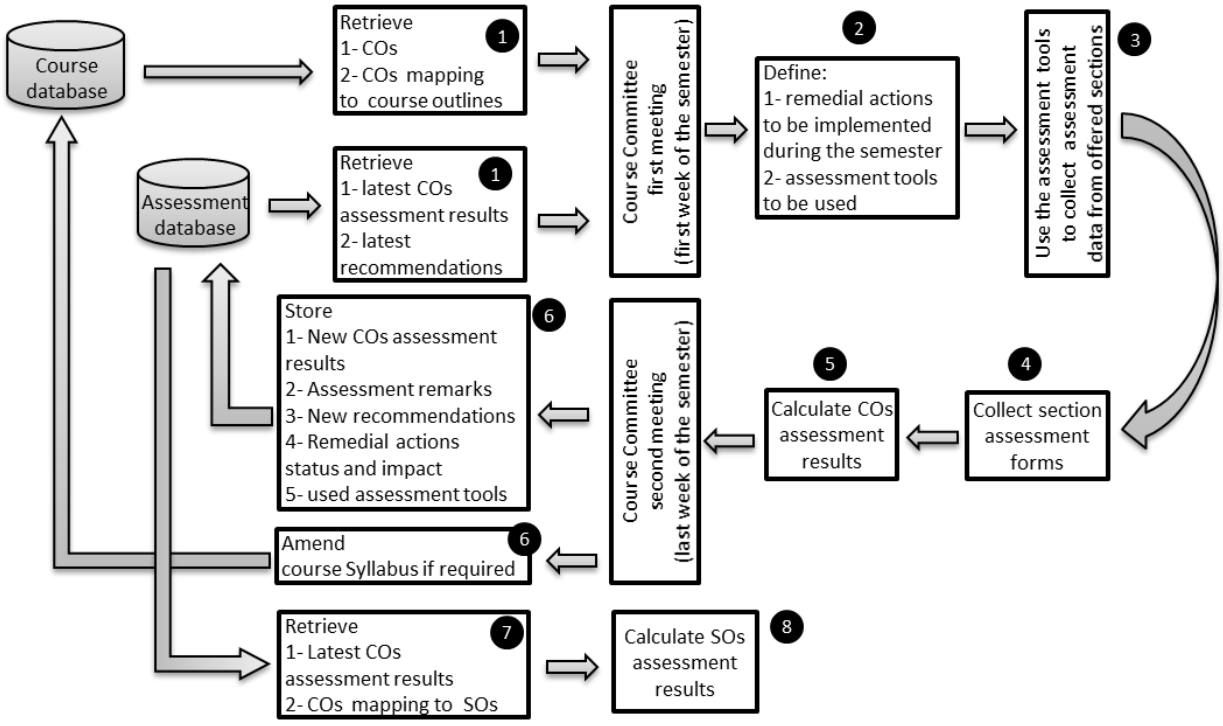

Figure 3. Proposed assessment model

To overcome these drawbacks, a new assessment model has been developed by the assessment committee of our College of IT, and subsequently approved by the College council during the 2008-2009 academic year (see figure 3). The new assessment process starts by defining COs for a new course or revising existing ones based on ABET standards for an IT curriculum and Bloom's taxonomy for cognitive skills. The curriculum committee at the College level is responsible for approving any alteration in COs requested by the corresponding course coordinator.

As part of the proposed model, a course assessment process requires that a *course committee* routinely convenes each time the course is offered. The course committee consists of the course coordinator (chair) and all other instructors who are teaching sections of that course during that offering. The course committee meets at least twice during the course offering. The first meeting is usually scheduled before the end of the first week of a course offering period. In

this meeting, the course committee (i) discusses the assessment results and recommendations from the last course offering, (ii) decides on a set of remedial actions to address the advocated recommendations in the previous assessment exercise, and (iii) agrees on the set of tools that will be used to assess each outcome (see figure 3 for examples of course assessment tools).

During the course offering, each instructor teaching the course is responsible for collating the assessment data for his/her own section(s) and preparing a simplified section assessment report. The section assessment reports are then sent to the course coordinator within two weeks after the administering the final exam. To minimize the assessment effort, the section assessment report includes only the following information:

- The number of students
- The assessment tools used
- The mean and standard deviation for each outcome achievement level
- Any assessment related remark (optional).

Although bi-modal distribution could be more appropriate in some situations to model the students' performance, the tool assumed a Normal distribution for the students' performance to facilitate the aggregation of the assessment data from different sections and different assessment instruments producing the overall CO assessment results. To calculate the mean and the standard deviation for each outcome, the course coordinator aggregates the performance of the students in each used assessment tool. We assume that each course c has a set of outcomes O_c, a set of assessment tools T_c, and is offered to a set of sections S_c. Therefore, the mean and standard deviation for outcome o is calculated as follows:

$$\mu_{soc} = \frac{\sum_{t \in T_c} \mu_{tsoc} \times \alpha_{to}}{\sum_{t \in T_c} \alpha_{to}} \qquad (1)$$

$$\sigma_{soc} = \sqrt{\frac{\sum_{t \in T_c} \sigma^2_{tsoc} \times \alpha_{to}}{\sum_{t \in T_c} \alpha_{to}}} \qquad (2)$$

Where μ_{tsoc} and σ_{tsoc} are the mean and standard deviation when tool t is used in section s to assess outcome o of course c, α_{to} is a mapping factor that determines the contribution of the assessment tool t to the achievement of outcome o such that $\sum_{o \in O_c} \alpha_{to} \leq 1$.

The course coordinator compiles the received section assessment reports, and calculates the aggregated course level assessment results. Using the mean and standard deviation for measuring the achievement of the outcomes at the section level facilitates the aggregation of the results from different sections to calculate the overall course assessment, regardless of the assessment tool used in each section. For each outcome o of course c, the aggregated mean and standard deviation are calculated as follows:

$$\mu_{oc} = \frac{\sum_{s \in S_c} \mu_{soc} \times n_s}{\sum_{s \in S_c} n_s}, \qquad (3)$$

$$\sigma_{oc} = \sqrt{\frac{\sum_{s \in S_c} \sigma^2_{soc} \times n_s}{\sum_{s \in S_c} n_s}}, \qquad (4)$$

where n_s is the number of students in section s. Assuming Normal distribution, the achievement level of outcome o of course c (noted A_{co} below) is calculated as the percentage of students who scored above a predefined cutoff threshold λ, as shown next:

$$A_{oc} = 0.5 - 0.5 \times erf\left(\frac{\lambda - \mu_{oc}}{\sigma_{oc} \times \sqrt{2}}\right). \quad (5)$$

For example, assume that μ_{co} = 0.74, σ_{co} = 0.093, and λ = 0.7, the outcome achievement level in this case is the percentage of students whose score is above λ, which in this case is 66.64%.

To close the assessment cycle, after aggregating the section assessment results, the course coordinator convenes the course committee for the second meeting. During that meeting, the committee reviews the remedial actions implemented during the last offering and evaluates their impact. The committee also compares the calculated achievement level for each outcome (A_{co}) against the targeted standard set by the College administration. Both the targeted achievement level and the cutoff threshold (λ) are proposed by the curriculum committee and approved by the College council. If any deficiency is identified, a new set of recommendations is created. After the second meeting, the course coordinator uses the online course assessment tool, presented later in this paper, to fill and submit the course assessment report.

It is important to mention that the effectiveness of the assessment process is very sensitive to the cutoff threshold (λ) and the achievement target level. These two values should be carefully set as they affect the continuous quality improvement cycle. For instance, setting either of these two values inappropriately low implies that there is a high probability that the outcome achievement level will be satisfied. Consequently, no recommendation or remedial actions will be needed, which stops the continuous improvement cycle prematurely. Therefore, if the CO targeted performance level is satisfied in two subsequent assessment cycles, the course coordinator might consider raising the performance bar. This is done by submitting a request to the curriculum committee for review, recommendation and approval. The curriculum committee may set different values for different courses depending on the course type and level. For example a targeted performance level for a mandatory core course in the curriculum could be set higher than the value used for an elective specialized course.

Course and assessment databases

To organize and control the access to course related information, a course database has been developed. The database is used to store all course related attributes such as catalogue description, textbook, credit hours, topical outline, grading criteria, pre-requisites, outcomes, and the name of the course coordinator. Access to this database is geared by a portal-based application, which sets proper authentication across different course-related stakeholders (faculty vs. program coordinator). The course database also maintains a mapping between the outcomes and the course topical outline. This mapping helps the course coordinators analyze the collected assessment data as it highlights which part of the course contributes to which outcome. As a result, course coordinators are able to make more relevant and effective recommendations by identifying the areas that need more attention when a deficiency in one of the outcomes is observed. The effectiveness of the recommendation is linked to the impact of the implemented remedial actions as observed by the instructors.

To simplify the collection and extraction of COs' assessment results, an assessment database was created. The assessment database is also used as an assessment data warehouse to keep a history of COs assessment related data across several course offerings. For each assessment cycle, this database stores the following information:

- total number of students,
- applied assessment tools,
- aggregated mean and standard deviation for each CO,
- assessment remarks for each CO, which might include a comparison between the performance of the students during the current offering and the previous one, or a comment on the effect of an remedial action.
- new recommendations,
- a description, status, and impact for each implemented remedial action,
- mapping between each new recommendation and the related COs, and
- mapping between the remedial actions and the previous recommendations.

The mappings in items 7 and 8 are paramount as they effectively document the closure of the assessment loop. For each deficiency, the database is used to retrieve the assigned recommendations and the remedial actions taken during the following assessment cycle. It can also be used to track the implementation of each remedial action and their impact. This allows course coordinators to adopt or reject an implemented remedial action based on its observed impact on the CO achievement. Remedial actions with a negative impact would be replaced by different ones during the following course offerings. In addition to the mean and STD stored in the database and used later for the calculation of the SOs, the performance of the students in the different assessment instruments used in the calculation of the assessment results are collected and stored in a separate repository.

The assessment database also maintains a mapping between COs and SOs, which allows the tool to utilize the COs' assessment results as an instrument for assessing SOs. Each CO may contribute to zero or multiple SOs, while one or multiple COs may contribute to the same SO. The CO contribution level to a specific SO depends on the number of course-related contact hours dedicated toward the achievement of the CO which is mapped to that SO. Assuming a 15 weeks course offering, a 3 credit-hours course can produce up to 45 contact hours to cover the different COs throughout the course offering. Therefore, assuming that the curriculum has a set of student outcomes O_S, and each course c has a set of outcomes O_C, the mapping function M_{ij} defines the number of contact hours a course outcome $i \in O_C$ contributes to a student outcome $j \in O_S$ such that:

$$\sum_{i \in O_c} \sum_{j \in O_s} M_{ij} \leq 45. \quad (6)$$

The course and the assessment databases form the back-end of our Web-based assessment tool. The tool is part of an integrated assessment portal that was designed and implemented during the preparation for the successful ABET accreditation exercise of our BS in IT program. The implementation details of this tool are further revealed next.

Web-based assessment tool

The Web-based assessment system is implemented on top of our existing curriculum management application developed as part of a College-wide portal. This allowed us to ingrate the academic assessment operations with some existing services such as online syllabi and (automatic) study plan generation for individual students (as part of our student advising process). The portal is implemented using Liferay portal development platform (Sezov, 2011). The selection of Liferay is due to its open architecture, which could also be seamlessly integrated into Course Management Systems like Moodle. We preferred this approach to separate course assessment from content management in order to facilitate change management and to link assessments with our College-wide admin processes that are already hosted in the Liferay-based portal.

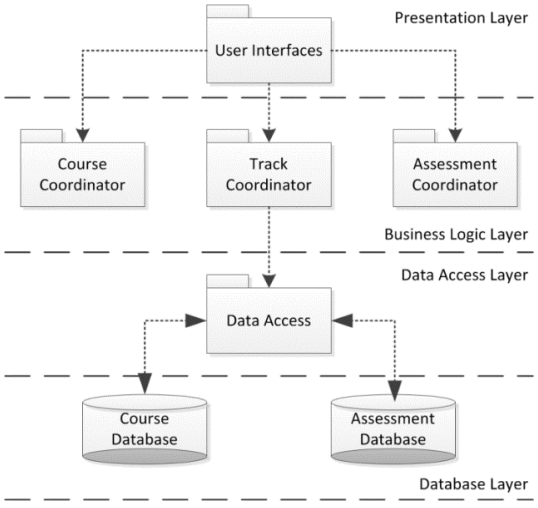

Figure 4. Assessment Portal Architecture

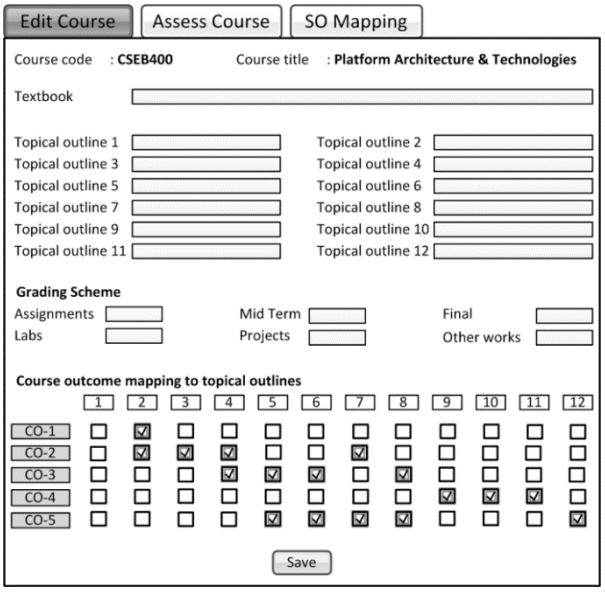

Figure 5. Course Editing Portlet

Figure 4 shows the implementation architecture following a common layered-structure, which includes: presentation layer, business logic layer, data access layer, and databases layer. In portal context, the presentation layer is fundamental since it expresses the required workflows across the entire layer hierarchy. The presentation layer comprises components used in the interactions between academic assessment related personnel and the customized user interfaces. The major role of the presentation layer is to display the information required at each assessment level (i.e., COs, SOs, and PEOs) as well as to translate user's instructions into business logic layer operations. The data access layer contains the collected raw assessment data and their organization into the portal-provided assessment database.

Using Liferay portal development platform, we generate customized presentation interfaces from our course and assessment databases. The portal which receives client requests, includes a *portlet* container. A portlet is a Web component (Java-based), which basically listens to client requests and generates dynamic contents accordingly using pre-defined templates. A portlet may accommodate several windows into a portal page. Figure 5 shows the portal page for a course coordinator. The page has three windows that allow the course coordinator to edit the course information (figure 5), edit COs mapping to SOs (figure 6), or assess the related COs (figure 7)

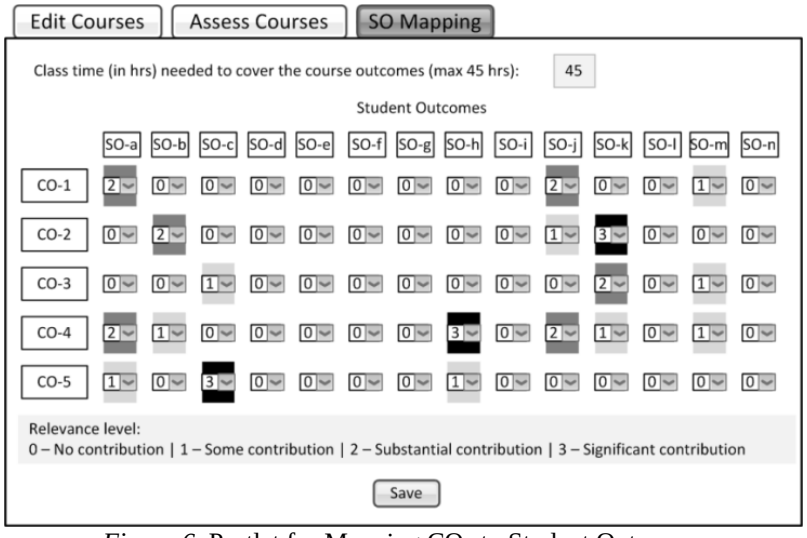

Figure 6. Portlet for Mapping COs to Student Outcomes

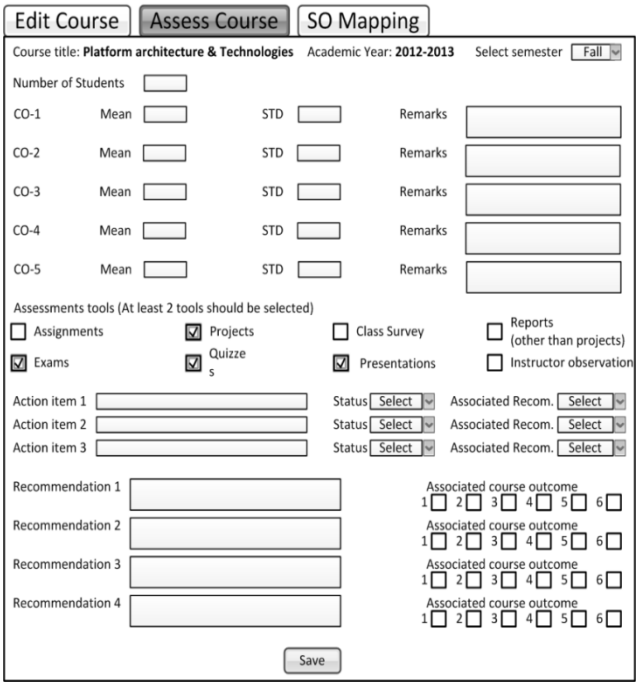

Figure 7. Course Assessment Portlet

Using the first window (see Fig 5) the course coordinator may update the course textbook, topical outlines, grading scheme, or the mapping between the COs and the topical outlines. Other information such as the course name, title, catalogue description, credit hours, and outcomes can only be modified by the curriculum committee. Although multiple sections of courses could be offered simultaneously each semester by different instructors, only the course coordinator is allowed to edit the course information or update the mapping between COs and SOs, and COs to the topical outlines. This ensures a uniform course offering with a common set of COs across the offered sections. However, the tool allows different courses to have different number of COs and topical outlines to accommodate the offered variety of courses at the different levels.

A course assessment form (see figure 6) is made available for instructors to enter relevant data for the current assessment cycle. According to the course assessment process, the course coordinator should complete the course assessment form once in each academic year. In addition to the outcomes means, standard deviations, and the used assessment instruments, the form also collects essential information regarding the assessment loop closure. This information includes the remedial actions taken during the semester to address the recommendations from the previous offering. For each taken action, the status and the associated recommendations are also specified. The form also lists the recommendations created by the course committee to address any new shortcomings. Each new recommendation is mapped to one or more CO. By clicking on the save button, the course coordinator signs and saves the assessment form in the assessment database. The assessment database simplifies the assessment loop closure significantly. It is now straightforward to query the database to list all the recommendations created to address a shortcoming in a specific year to trace its impact. The action items created to address those recommendations, as well as the status of each one can also be retrieved and traced.

The third window is used to map COs to the standard "14 SOs" defined by our IT program. The portlet assumes that each course has a maximum of 45 contact hours, which can be used to contribute to the SOs (as described earlier). To simplify the mapping process, instead of specifying the number of hours, the course coordinator may set the mapping level to either none, some, substantial, or significant, which is respectively translated by the portlet to 0, 1, 3, or 6 contact hours. The portlet allows the course coordinator to set and adjust the contribution level of each CO, however it prevents any further contribution if the accumulated contact hours reached the 45 hours limit. The saved mapping information is then used along with the COs assessment results (mean, and STD) to automate the calculation of SOs achievement results.

Discussion

Since its deployment in Spring 2008, the assessment portal witnessed increased access frequency by academic personnel in our institution as shown in figure 8 considering there are about 32 course coordinators (some of whom are looking after multiple courses). Table 1 shows the assessment statistics for Fall 2009. It shows that 85.7% of the offered courses have at least the mean and standard deviation of the COs submitted, while only 50% of course coordinators used the assessment remarks to comment on the new assessment results. The number of courses with at least one recommendation increased from 16.67% in Spring 2009 to 69.1% in Fall 2009. Out of the courses with submitted recommendations in Spring 2009 (16.67%), only 52.17% have implemented at least one action item during Fall 2009.

Table 1. Fall 2009 Course assessment statistics

Courses with COs Mean and STD	85.7%
Courses with assessment remarks	50%
Courses with previous recommendations	16.67%
Courses with at least one action item	52.17%
Courses with at least one new recommendation	69.1%

The tool was introduced to the course coordinators during one of the regular faculty meeting followed by a workshop on the new course assessment process and on how to use the tool to fill and submit a course assessment report. During the initial deployment of the tool, the existing curriculum related information (e.g., course titles, catalogue descriptions, credit hours, textbook titles, etc.) was easily collected and uploaded to the course database by administrative personnel. Course coordinators were then asked to complete the following related tasks: (i) revising current COs, (ii) mapping the revised COs to SOs, (iii) mapping the revised COs to course outlines, and iv) use the provided portal interface to upload these information to the course database. Setting the completion of these tasks as one of the milestones for ABET accreditation and with the proper and timely guidance, course coordinators were able to complete these tasks appropriately within the allowed time.

Figure 9 shows the percentage of courses with the assessment form completed by the course coordinator for the last four years. It shows that the percentage of the course assessment increased significantly from 34.2% in 2008-2009 to 85.5% in 2009-2010. We believe that this significant increase is due to two main reasons. First, the tool was deployed late in the second semester of 2008-2009. Hence, the tool was used only for a subset of the courses offered in the second semester. Second, the increased assessment and accreditation activities within the college during 2009-2010 in preparation for the ABET accreditation review had improved the assessment awareness within our College. Figure 9 shows that the percentage of assessed courses improved back to 80% in 2011-2012 (following the successful accreditation outcome), after a slight decline in 2010-2011. This observation indicates the sustained assessment efforts facilitated by our streamlined electronic approach.

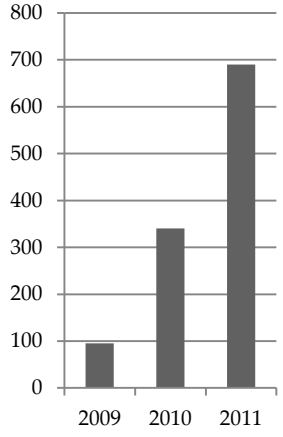

Figure 8. Assessment tool access by academic personnel

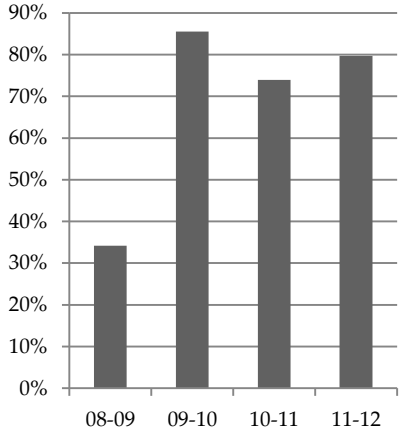

Figure 9. Percentage of assessed courses for the last four years

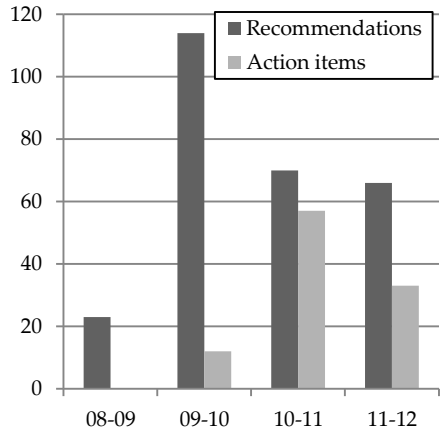

Figure 10. Number of recommendations and remedial action Items for the last four years

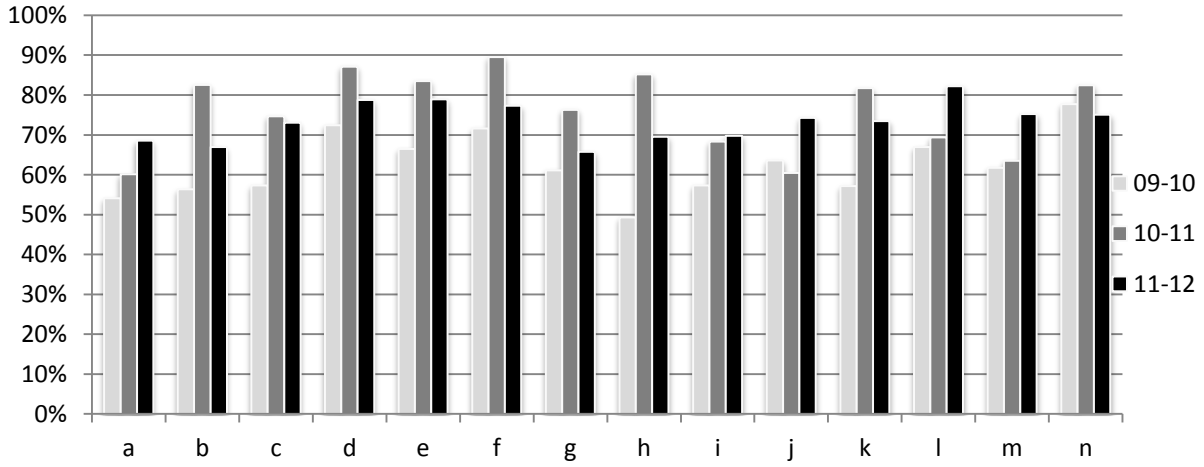

Figure 11. Percentage of 70% achievement for the 14 SOs for Three Consecutive Years

Over the last four years we have overseen the implementation of the course assessment process and the usage of the web-based tool. We noticed that the main difficulty facing course coordinators was the collection of the assessment data and the calculation of the COs assessment results. No complaint has been received from the course coordinators regarding the usability of the web-based tool. Therefore, to overcome this difficulty, the assessment committee has developed new macro-based course assessment templates that automate the calculation of the assessment data from individual sections and aggregate them to calculate the COs assessment results. The templates were deployed during the 2013/2014 academic year with positive feedback received from course coordinators on how these templates significantly simplified the course assessment process. We are planning to develop an online version of the templates and integrate them within the assessment portal during the 2014/2015 academic year.

The impact of the new course assessment and its Web-based tool is twofold. First, it helps improving the quality of the curriculum by improving the quality of individual courses. Using the course outlines to COs mapping feature helps course coordinators to create effective recommendations that target areas of deficiencies. The evidence of this statement is shown in figure 10, a total of 114 recommendations were submitted in 2009/2010 academic year to address the identified deficiencies in COs assessment. A total of 57 remedial actions were implemented during the 2010/2011 academic year to address some of these recommendations, which exceeds by large margins of previous manual processes.

In this study the curriculum improvement is assessed by the achievement level of SOs. Figure 11 presents the percentage of SOs which successfully exceeded the 70% threshold for three consecutive assessment cycles. The percentage is calculated using only COs assessment results, and the COs to SOs mapping provided by the course coordinators. It shows a clear positive improvement in the achievement of SOs since the first assessment cycle after the tool deployment in the 2009-2010 academic year. It reveals that throughout that same academic year, six out of the 14 outcomes were below the 60% achievement-threshold target. While none of the SOs were below the 60% achievement threshold in the following two assessment cycles.

However, as shown in figure 10, only 47% and 52% of the recommendations developed in an assessment cycle were implemented using action items during the following cycle. This is considered a serious deficiency since implementing the recommendations through remedial actions and measuring their impacts is essential for closing the assessment loop. This deficiency usually occurs when the course coordinator ignores calling the course committee to meet at the beginning of the semester to discuss the previous assessment report and decide on the appropriate action items to implement, as outlined in the proposed assessment model.

The suggested Web-based application has also a positive impact on the achievement level of SOs. The tool automatically assesses the SOs by using the submitted course assessment results, and the mapping between COs and SOs maintained by the assessment database. This has prompted the academic assessment coordinator to use the course assessment results, for the first time during the 2009-2010 academic year as a tool to assess SOs. We believe that using the course assessment results as one of the assessment instruments has enhanced the accuracy of SOs

assessment process, which used to depend only on the student performance in administrated exit exams and surveys. The impacts of the provided Web-based assessment tool motivated an increasingly larger population of academics to embrace an outcomes-based education and in extending the dynamics of curricular revisions. The observations drawn from a three-years processing of assessment results illustrate improvements in outcomes achievement that are attributed to the provided Web-based assessment tool.

Conclusions

In this paper, we introduced a new course assessment approach and a supporting Web-based application to streamline the overall processing of collected assessment data. The Web-based application provides a user-friendly interface to the course coordinator, the curriculum committee, and the academic assessment coordinator, for accessing the assessment results as well as tracking the related recommendations and the status of the remedial actions.

One of the main objectives of the accreditation review is to ensure that students are achieving the intended outcomes through a continuous quality improvement process. The proposed tool has proved to increase the stakeholders' rate of contribution into the academic assessment process. Based on the observed results, a consistently high rate of input is collected from course coordinators to impact the curriculum quality. This is an indication of the level of trust in the provided Web based tool to intervene in the process of optimizing the performance of academic programs administration. The opportunity to streamline the outcomes assessment process directly from course coordinators, has greatly contributed to identify areas of deficiencies to close effectively the assessment loop. This procedural engagement translated into remedial actions and related documentation to address and track the discovered deficiencies and to reflect back on the recommended enhancements.

References

Al-Yahya S. A., & Abdel-Halim, M. A. (2013, May). A successful experience of abet accreditation of an electrical engineering program. *IEEE Transactions on Education*, *56(*2), 165-173. doi: 10.1109/TE.2012.2206112

Black, P., & Wiliam, D. (1998, November). Inside the black box: Raising standards through classroom assessment. *Phi Delta Kappan*, *80*, 139–44.

Booth, L. (2006, October). *A database to promote continuous program improvement*. Paper presented at the 7th Conference on Information Technology Education, Minnesota, USA.

Brennan, R., & Hugo, R. (2010, June). *The CDIO syllabus and outcomes-based assessment: A case study of a Canadian mechanical engineering*. Paper presented at the 6th International Conference CDIO, Montreal, Canada.

Crespo, R. M., Najjar, J., Derntl, M., Leony, D., Neumann, S., Oberhuemer, P., Totschnig, M., Simon, B., Gutierrez, I., & Kloos, C. D. (2010, April). *Aligning assessment with learning outcomes in outcome-based education.* Paper presented at the IEEE Education Engineering Conference , Madrid, Spain.

Dew, S. K., Lavoie, M., & Snelgrove, A. (2011, June). *An engineering accreditation management system.* Paper presented at the 2nd Conference Canadian Engineering Education Association, St. John's, Newfoundland, Canada.

Joint Information Systems Committee (2007). *Effective practice with e-assessment: An overview of technologies, policies and practice in further and higher education*. Retrieved March 17, 2014, from http://www.jisc.ac.uk/media/documents/themes/elearning/effpraceassess.pdf

Essa, E., Dittrich, A., Dascalu, S., & Harris, F. C. (2010, April). *ACAT: a web-based software tool to facilitate course assessment for ABET accreditation*. Paper presented at the 7th International Conference Information Technology: new generations, Las Vegas, USA.

Gardiner L. F. (2002). Assessment essentials: Planning, implementing, and improving assessment in higher education (review). *J. Higher Education*, *73*(2), 302–305.

Harden, R. (2002). Developments in outcomes-based education. *Medical teacher*, *24*(2), 117–120.

Harden, R. (2007). Outcomes-based Education: The future is today. *Medical teacher*, *29*(7), 625–629.

Kerr B. (2011, September). *Using a web-based assessment tool for accreditation and program improvement*. Paper presented at Interactive Collaborative Learning, Piestany, Slovakia.

Rogers G. M. (2012). Assessment of student learning outcomes. Retrieved March 17, 2014, from http://www.abet.org/assessment.shtml#Assessment

Sanderson, D. B. (2009, March). *Revising an assessment plan to conform to the new ABET-CAC guidelines*. Paper presented at the 40th ACM Technical Symposium on Computer Science Education (pp. 352–356), Chattanooga, USA.

Sezov R. (2011). *Liferay in Action: The official guide to liferay portal development*. Shelter Island, NY: Manning Publications.

Wergin, J. F. (2005). Higher education: Waking up to the importance of accreditation. *Change*, *37*(3), 35-41.

Williams J. M. (2010). Evaluating what students know: Using the RosE portfolio system for institutional and program outcomes assessment tutorial. *IEEE Transactions on Professional Communication*, *53*(1), 46–57.

Wyne M. F. (2010, April). *Ensure program quality: assessment a necessity*. Paper presented at IEEE engineering education. Madrid, Spain.

Yue, K. B. (2007). Effective course-based learning outcome assessment for ABET accreditation of computing programs. *Journal of Computing Sciences in Colleges*, *22*(4), 252–259.